# Space Weather Technical Forecast

Issued on Wednesday, 15 June 2022 at 01:28 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: G1 (Minor Storm) conditions likely Day 1 (15th), with a chance of a G2 (Moderate)Storm. Chance of M-class flares. Slight chance of S1/Minor Solar Radiation Storms on all days. Slight chance of Active fluence Day 4 (18th).**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity was Low in the last 24 hours with several mid-high level C-flares observed emanating from AR3031, AR3030 and AR3036. There are eight sunspot regions on the visible disc, the largest and most complex of which is AR3031 in the southern centre disk. No earth-directed CMEs have been observed.

**Solar Wind / Geomagnetic Activity:** The solar wind speed, as observed by DSCOVR at L1, varied between 430-540 km/s. Density was mostly average with short-lived periods above average. A peak density of 15ppcc was observed at 14/0556 UTC. The Total Interplanetary magnetic field strength, Bt, erratically decreased from moderate to weak during the period. The north-south component, Bz, varied weakly between +8/-6 nT. The phi angle was mostly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled.

**Energetic Particles / Solar Radiation:** The high energy proton flux (10 MeV) was at slightly above background levels, but with no solar radiation storms thresholds reached. Electron flux (greater than 2MeV) was at background to moderate levels. Corresponding 24-hour integrated electron fluence has been well below the Active (1e8 integrated pfu) threshold on a slight rising trend. 3.09e6 integrated pfu was observed at 15/0000UTC.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Solar activity is expected to be Low or Moderate, with M-class flares likely and a very slight chance of X-class flares, which would allow activity to become High.

**Solar Wind / Geomagnetic Activity:** A large CME was observed leaving the sun in the early hours of the 13th, in association with a long duration M3 flare. Its analysis revealed that while the bulk of the ejecta is expected to miss behind Earth's orbit, a glancing blow early on the 15th is likely. Solar wind speeds are expected to be at slightly elevated to elevated levels early on the 15th, perhaps increasing to strong for a time with the anticipated arrival of the indicated CME. Solar winds are then likely to be at mainly elevated levels through to the 18th with the onset and continuation of two high speed streams from coronal holes. Winds may return to slightly elevated levels later on the 18th.

Geomagnetic activity is likely to be Quiet or Unsettled initially, becoming Active or G1/Minor Storm, with a chance of a G2/Moderate Storm interval early on the 15th. Geomagnetic activity should then ease to become mainly Unsettled later in the day, however, the arrival of a high-speed stream early on the 16th may increase activity back to Active or G1/Minor Storm levels. Mainly unsettled activity is expected later on the 16th, though perhaps becoming Active again with the anticipated onset of another coronal hole on the 17th. At other times with any prolonged periods of negative Bz with elevated winds could see a chance of further Active or perhaps G1/Minor Storm intervals, but with a reducing risk over time.

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**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10 MeV) is expected to be at background, or just above background levels during the period, with a slight chance of S1/Minor Storm conditions occurring. High energy electron flux (greater than 2 MeV) is expected to start at background levels with a chance of increasing to moderate or perhaps high levels later in the period, due to high speed stream influences. Electron fluence is expected to follow a slow rising trend, with a slight chance of reaching Active (1e8 integrated pfu) levels on the 18th.

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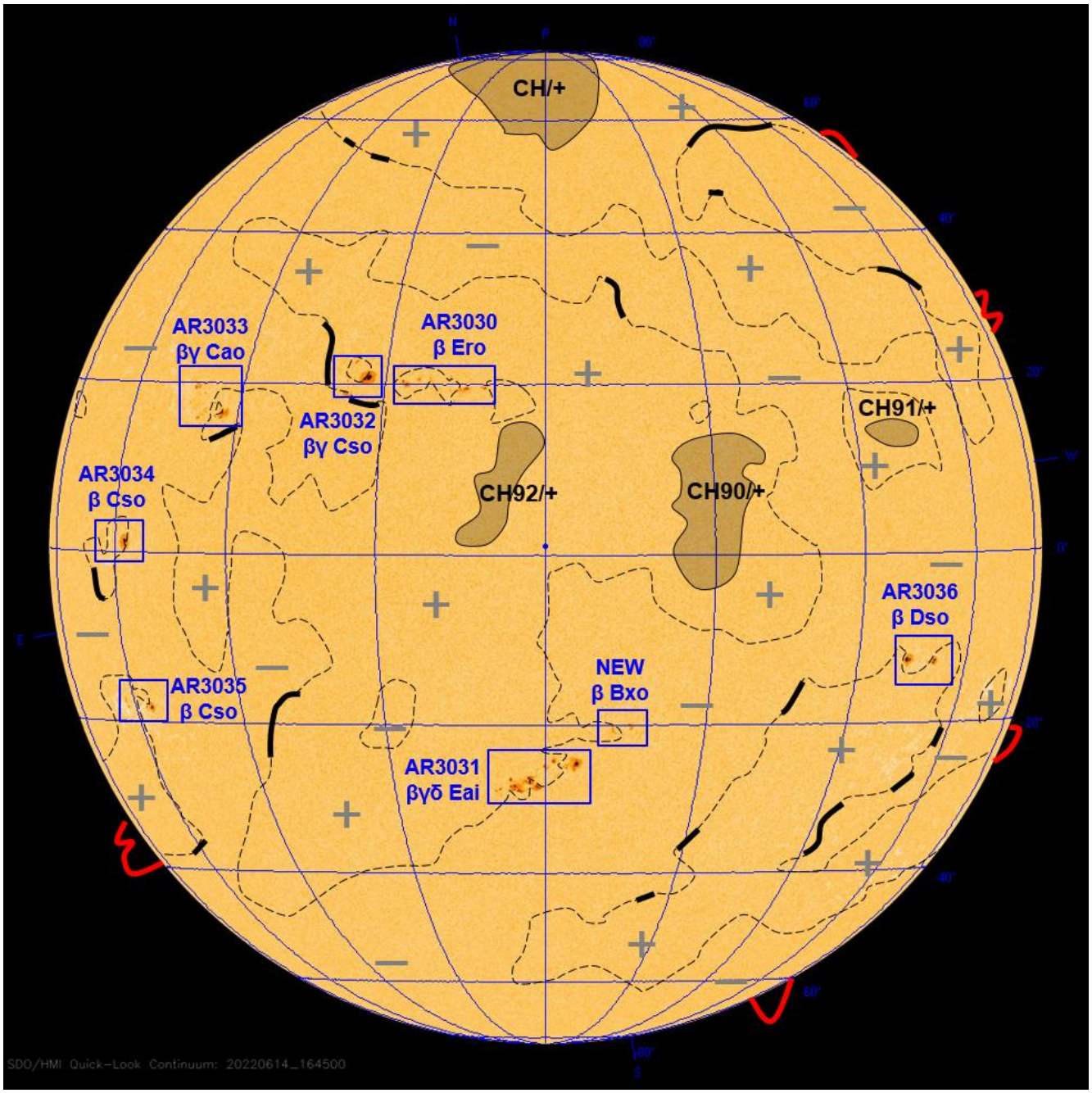
**Figure 1. Solar Analysis Valid 14/1645 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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# Met Office Space Weather Technical Forecast

## Geomagnetic Storms:

Earth is likely to receive a glancing blow from the large CME which left the Sun on the 13th. STEREO-A appears to have encountered this CME around 14/1800 UTC. This fits well with Enlil modelling of the feature, so confidence is moderate to high for an arrival at Earth around 15/0300 UTC +/- 3 hours. The speed of this CME was analysed to be around 1100 km/s as it left the sun and may bring strong winds speeds at Earth, approximately 550-650 km/s should it arrive. No other CMEs are currently expected to affect Earth during the period.

Recent increases in the solar winds suggest that Coronal hole 91/+ may have arrived at Earth, with speeds elevated or slightly elevated. This increase may be superseded by the expected arrival of the CME early on the 15th, perhaps increasing winds to strong levels for a time. Solar winds may erratically decrease later on the 15th, before further increases in the solar wind are anticipated with the onset of Coronal Hole/90+ early on the 16th and then Coronal Hole/92+ on the 17th, continuing into the 18th. Mainly elevated winds would be expected from the 16th onwards.

Geomagnetic activity is likely to be Quiet or Unsettled initially, becoming Active or G1/Minor Storm, with a chance of a G2/Moderate Storm interval early on the 15th. Geomagnetic activity should then ease to become mainly Unsettled later in the day, however, the arrival of a high-speed stream from a coronal hole (CH90/+) early on the 16th may increase activity back to Active or G1/Minor Storm levels. Mainly unsettled activity is expected later on the 16th, though perhaps becoming Active again with the anticipated onset of coronal hole/92+ on the 17th. At other times with any prolonged periods of negative Bz with elevated winds could see a chance of further Active or perhaps G1/Minor Storm intervals, but with a reducing risk over time.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 70 | 60 | 40 | 20 |
| Strong | G3 | No | 5 | 3 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 13/0833 | Partial | AR3032 M3 flare | NE Limb | 1100km/s | 15/0300 UTC +/- 3 hours | Glancing blow likely |

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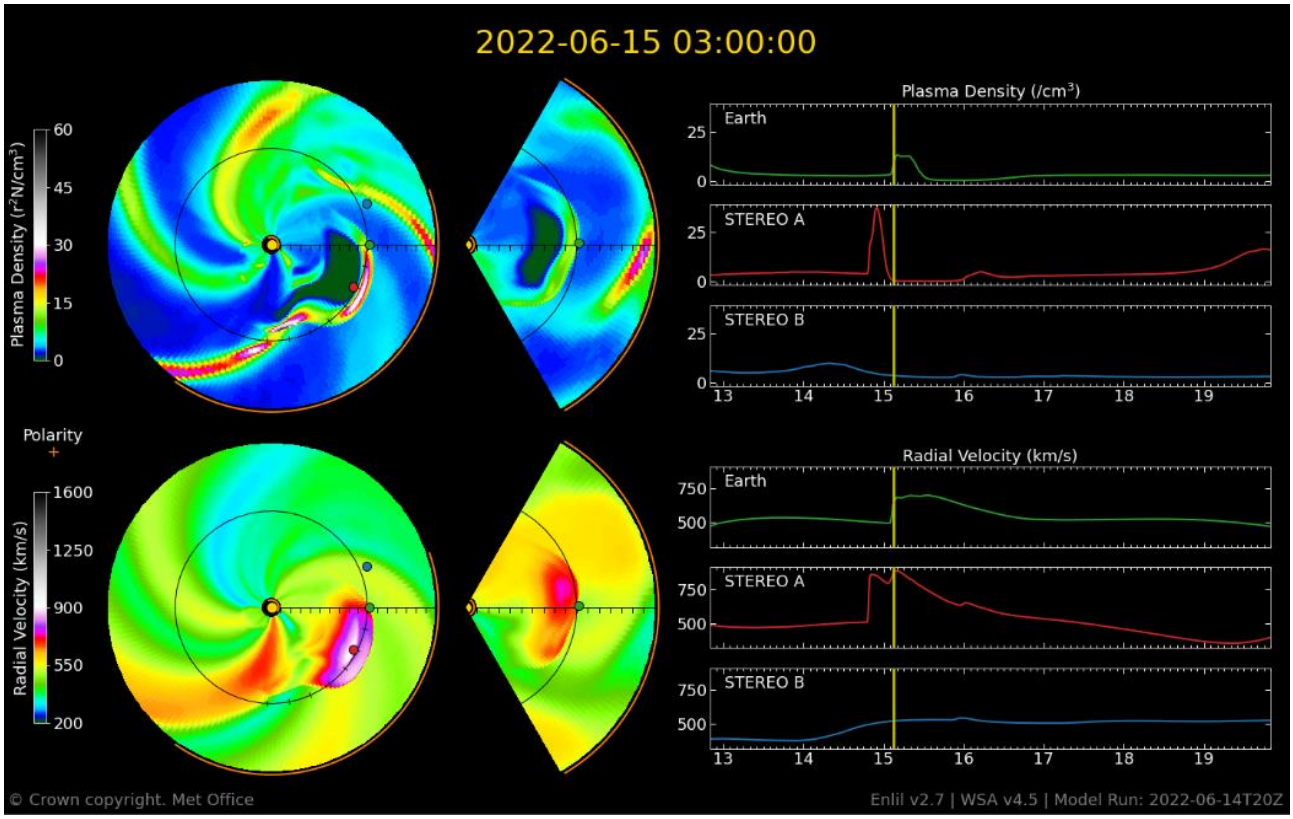
**Figure 2: MOSWOC ENLIL output indicating expected arrival of CME at Earth around 15/0300 UTC.**

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## Radio Blackouts - X-Ray Flares:

Solar activity is currently Low, with several mid-high level C-flares observed in the past 24-hours, emanating from AR3031 (Eai/Beta-gamma-delta), AR3030 (Ero/Beta) and AR3036 (Dso/Beta).

There are currently eight sunspots on the visible disk. AR3031 in the southern hemisphere, near the centre disc, poses the greatest risk at present for significant flares, given that it is a moderately large group with a number of fairly strong intermediate spots, including the presence of at least one delta spot. AR3030 near the centre disc in the northern hemisphere is a large group, longitudinally, but no strong evidence of penumbra exists at present.

All other sunspots are rather simple, bipolar regions at this time, with no strong evidence of emergence or significant development.

Solar activity is expected to be Low or Moderate, with a very slight chance of activity becoming High, mainly due to the ongoing development of AR3031. Although AR3036 will rotate over the eastern limb in the coming days, probabilities of both M-class and X-class flares are retained as one or more bright regions in the EUVI/AIA 195 imagery, that may contain sunspots, will rotate onto the earth-facing disc in the next couple of days.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 50 | 50 | 50 | 50 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 5 | 5 |

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## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) was at background levels but has been slightly elevated since around 13/2100 UTC. The risk of a proton storm remains very low, but a slight chance of S1/Minor Storm conditions is present on all days.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is currently at background to moderate levels. Similar conditions are expected to persist between the 15-17th with the electron belts suppressed due to the influence of a CME and at least two coronal holes that follow. The risk of the electron flux becoming moderate or high increases as the high speed stream begins to weaken on the 18th, allowing the Van Allen radiation belts to recharge themselves. This will marginally increase the risk of fluence levels reaching the Active (1e8 integrated pfu), though this is much more likely to occur after the 18th.

REFM output is considered to be unreliable at this time for the first three days of the forecast, given the anticipated arrival of the CME that will subdue electron counts. A rise on the 18th is likely to occur, but likely well below forecast and the Active threshold.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 1 | 3 | 20 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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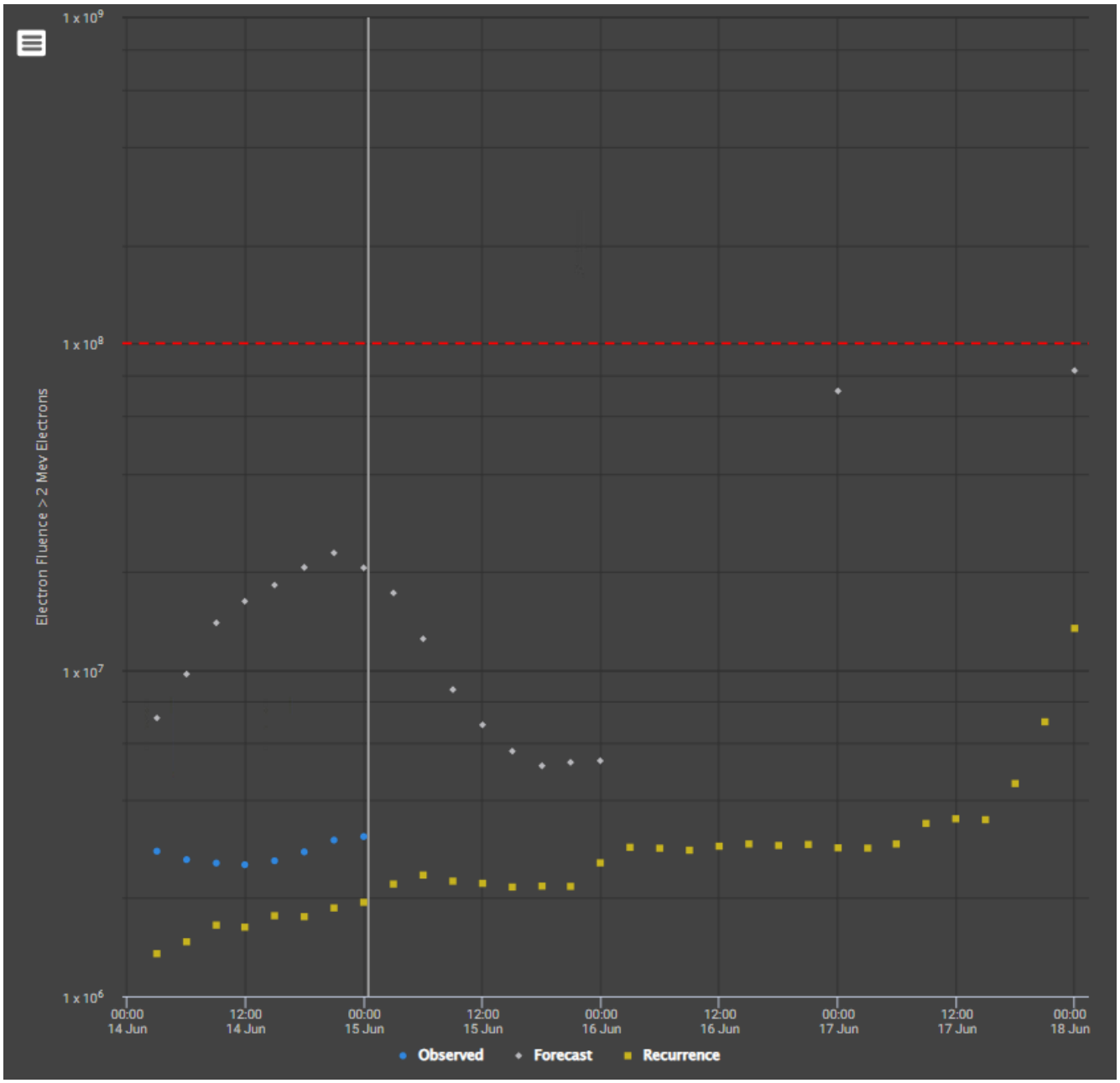
**Figure 3: GOES-16 Electron Fluence with REFM**

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